4: (3 Points) Transmission Media

Course Learning Outcome #3:
Identify the characteristics of the various transmission media.

(a) (1 Point) Two antennas are used for LOS transmission. If one antenna is **75 m** high and the other is **18.75 m** high, what is the **maximum distance** between the two antennas? Assume K = 4/3.

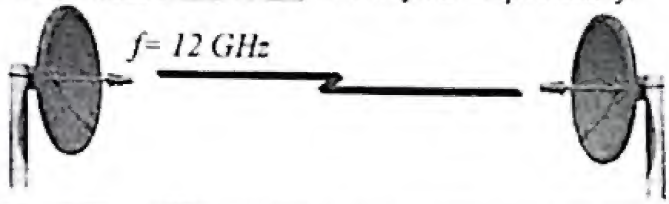
$\sqrt{\frac{4}{3}\times 75}$

$d = 3.57(\sqrt{Kh_1} + \sqrt{Kh_1})$

$= 3.57(\sqrt{100} + \sqrt{25})$ $\sqrt{\frac{4}{3}\times 18.75}$

$d = 53.55\,m$

(b) (1 Point) Two identical parabolic antennas are used for microwave communications at **12 GHz**, both of them have **6 m** diameter. If the speed of light is **3×10⁸ m/s**, Deduce the <u>**gain (G)** of each antenna in **decibels**</u>. Show your steps clearly.



6.25×10^{14}
6.72×10^{-14}

$\lambda = \frac{c}{f}$ $\quad G_{dB} = 10\log_{10}(\frac{7A}{\lambda^2})$ $\quad A_e = 0.56A$ $\quad G_{dB} = 10\log_{10}(\frac{4\pi}{\lambda^2}A_e)$

$\lambda = \frac{3\times10^6}{12} = 250000000$

$G_{dB} = 10\log_{10}\left(\frac{7\times6}{250000000}\right) = 10\log_{10}\left(\frac{42}{6.25\times10^{14}}\right)$

$10\log_{10}(6.72\times10) = 131\,dB$

-1

(c) (1 Point) Two identical parabolic antennas are used for microwave communications with carrier wavelength (λ) of **0.025 m**. Given the gain (G) of each antenna is **50 dB** and the distance between these two antennas is **14000 m**, deduce the **free space loss in decibels**. Show your steps clearly.

d

$L_{dB} = 20\log(4\pi) + 20\log d - 20\log\lambda - G_{dB} - G_{dB}$

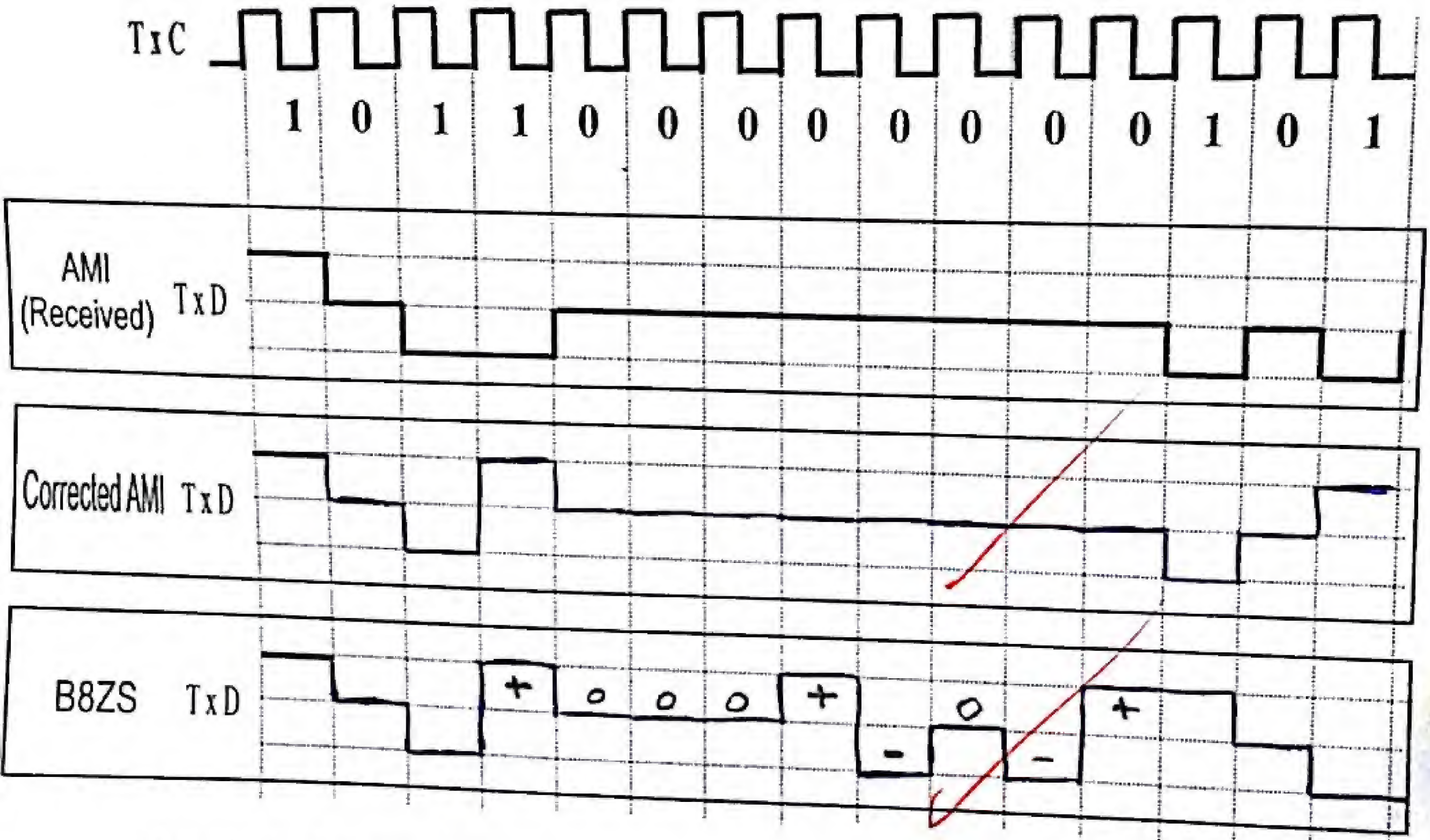
$L_{dB} = 20\log(4\pi) + 20\log(14000) - 20\log(0.025) - 50$ $\quad -50$

$= 21.98 + 82.92 + (-32.04) - 50$ $\quad -50$

$LdB = 86.94 - 50 = 36.$

-1.5

(a) **(3 Points)** The bipolar-AMI waveform representing the binary sequence 101100000000101 is transmitted over a noisy channel. If the AMI received signal is shown in the following figure:



Answer the following questions:

(i) (½ Point) If errors do exist, circle the error positions on the received AMI signal.

(ii) (½ Point) If errors do exist, draw the corrected AMI signal.

(iii) (1 Point) If the same binary sequence was transmitted using B8ZS, determine the output of the digital encoder.

+	0	0	0	+	-	0	-	+	-	0	0	0	-	+	0	+	-

(iv) (1 Point) Determine the advantage of the received B8ZS signal over the AMI signal.

AMI we have Proplem with 0s Now with B8ZS fixt
alack of Synchronization.

Points) Complete the following table to compare among the encoding schemes.

Hint: You need to write either YES or NO. For each incorrect answer, ½ point will be deducted.

Encoding Scheme	DC Component	Lack of Synchronization	Error Detection	Noise Immunity	Clock Extraction	Cost (Higher signal rate)
AMI (1 Point)	None	long Sequence of 0s	Yes	No	~~Yes~~	No
Manchester (1 Point)	None	None	Yes	Yes	Yes	Yes

(c) **(2 Points)** The theoretical Bit Error Rate (BER) for various encoding techniques is illustrated in the following chart. Assume that **AMI** encoding is used and the bandwidth efficiency is **2 bps/Hz**. If we are interested to have **10^{-4}** BER, deduce the signal to noise ratio (SNR) in __decibels__.

Hint:

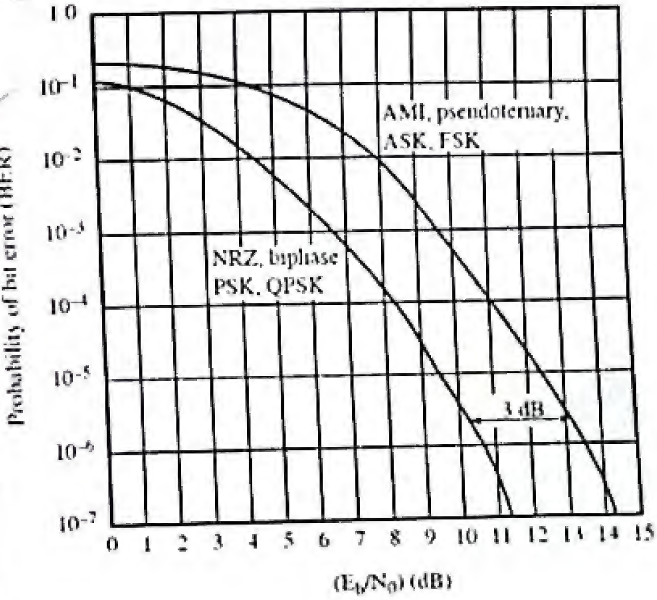
$E_b/N_o = 11$

$(E_b/N_0)_{dB} = ?$ $10\log_{10} E_b/N_o$
$= 10^{1.1} = 12.58dB$

$E_b/N_0 = ?$ 11

12.58dB

$(R/B)_{dB} = ?$ $10\log_{10} 2$
$= 3.01 dB$



$(S/N)_{dB} = 10\log_{10}(E_b/N_0 \times R/B)$ → $(S/N)_{dB} = (E_b/N_0)_{dB} + (R/B)_{dB}$

$(S/N)dB = (Eb/N_o)dB + (R/B)dB$
$(S/N)dB = 12.58 + 3.01$
$= 14.01 dB$

2. (5 Points) Answer the following questions related to DIGITAL DATA to ANALOG SIGNAL encoding:

(a) (1 Point) Obtain the baud rate for a 64,000 bps 16-QAM signal (M=16 levels)?

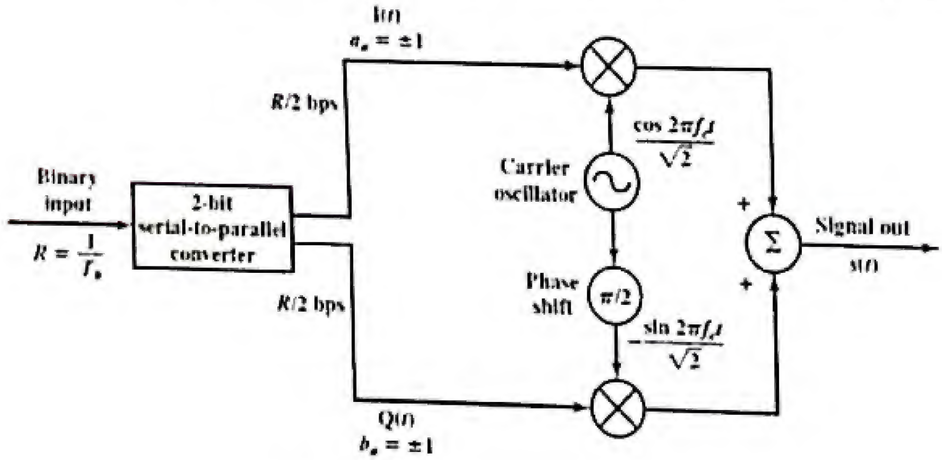
M = 4

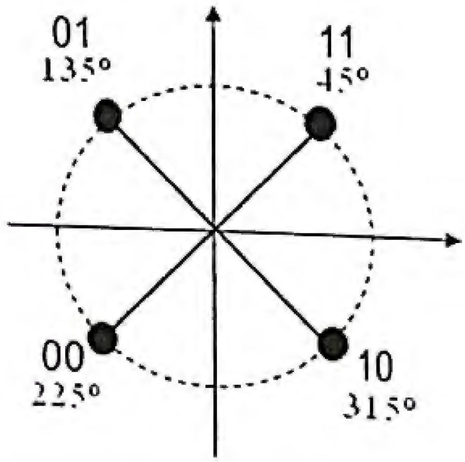
~~R = BW = 2fc = 16 baud~~

16000

-1

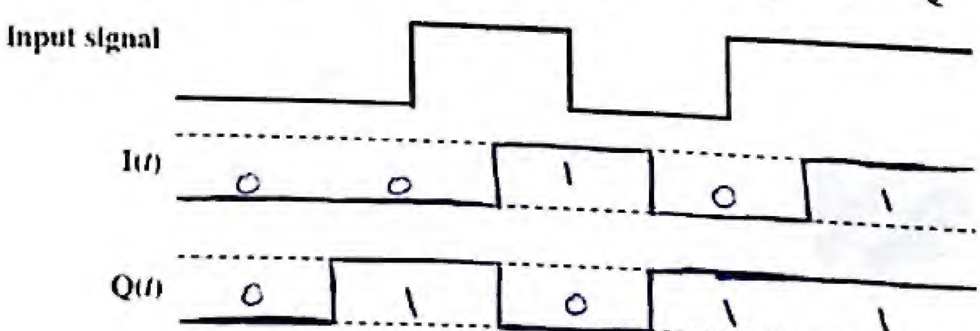
(b) (2 Points) Given the following QPSK modulation system:





Complete the following figure by finding out I(t), Q(t), and phase of the transmitted signal.

bit number	1	2	3	4	5	6	7	8	9	10
value	−1	−1	−1	1	1	−1	−1	1	1	1
	I	Q	I	Q	I	Q	I	Q	I	Q



phase of output signal

00	01	10	01	11
225°	135°	315°	135°	45°

-1

(c) (2 Points) A digital signal is encoded ... frequencies.
The carrier frequency f_c = 400 kHz and the difference frequency f_d = 20 kHz.

(i) (1 Point) Calculate the frequency for each of the 3-bit combinations.

$f_i = f_c + (2i - 1 - M) f_d \, , 1 \le i \le M$

f_c = 400 kHz , f_d = 20 kHz, M = 8

i	1	2	3	4	5	6	7	8
binary	000	001	010	011	100	101	110	111
f_i kHz	? 260kHz	? 300kHz	? 340kHz	? 380kHz	? 420kHz	? 460kHz	? 500kHz	? 540kHz

(ii) (1 Point) Calculate the total bandwidth required and the supported data rate.

$W_d = 2Mf_d$ $\quad$ Wd = 2 × 8 × 20 = 320 kHz

$R = 2mf_d$ $\quad$ R = 2 × 3 × 20 = 120 kbps

f_1	400 − 7×20	260 kHz
f_2	400 − 5×20	300 kHz
f_3	400 − 3×20	340 kHz
f_4	400 − 20	380 kHz
f_5	400 + 20	420 kHz
f_6	400 + 3×20	460 kHz
f_7	400 + 5×20	500 kHz
f_8	400 + 7×20	540 kHz

Points) Answer the following ...

SIGNAL encoding:

(a) **(1 Point)** Determine the **PCM bit rate** for a signal with 3100 Hz bandwidth (from 300 Hz to 3400Hz) and with **32** quantization levels. $M = 5$

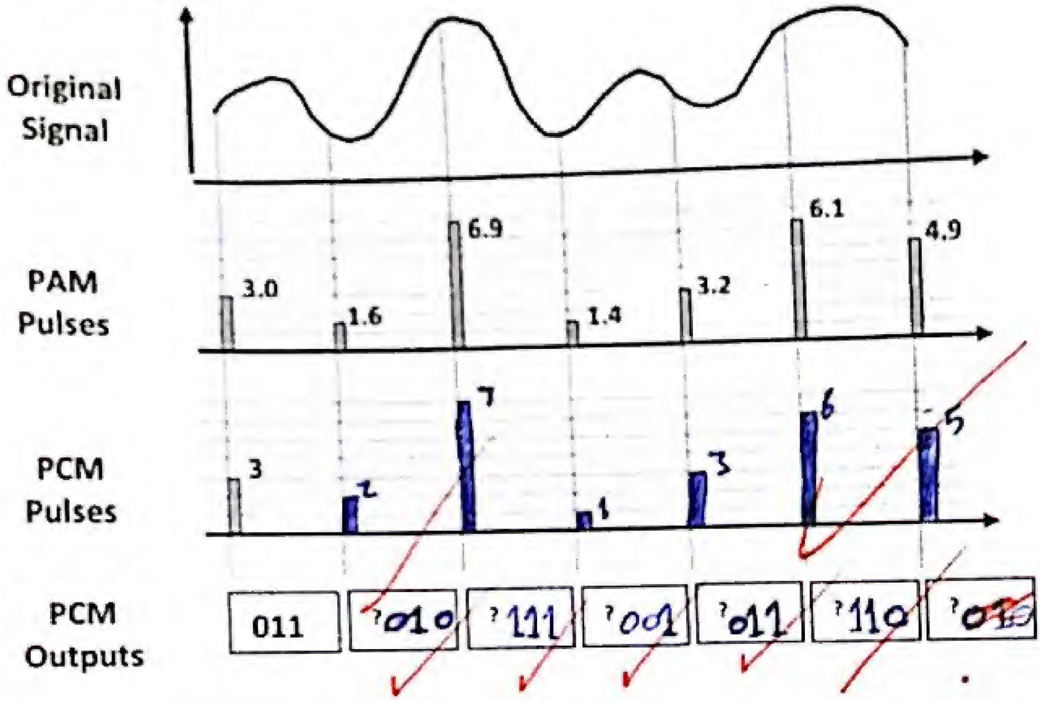
bit rate = Bw = $2 \cdot f_c$ = 5 baud

-1

(b) **(1 Point)** Complete the following figure by showing both:

(i) **(½ Point)** PCM pulses.

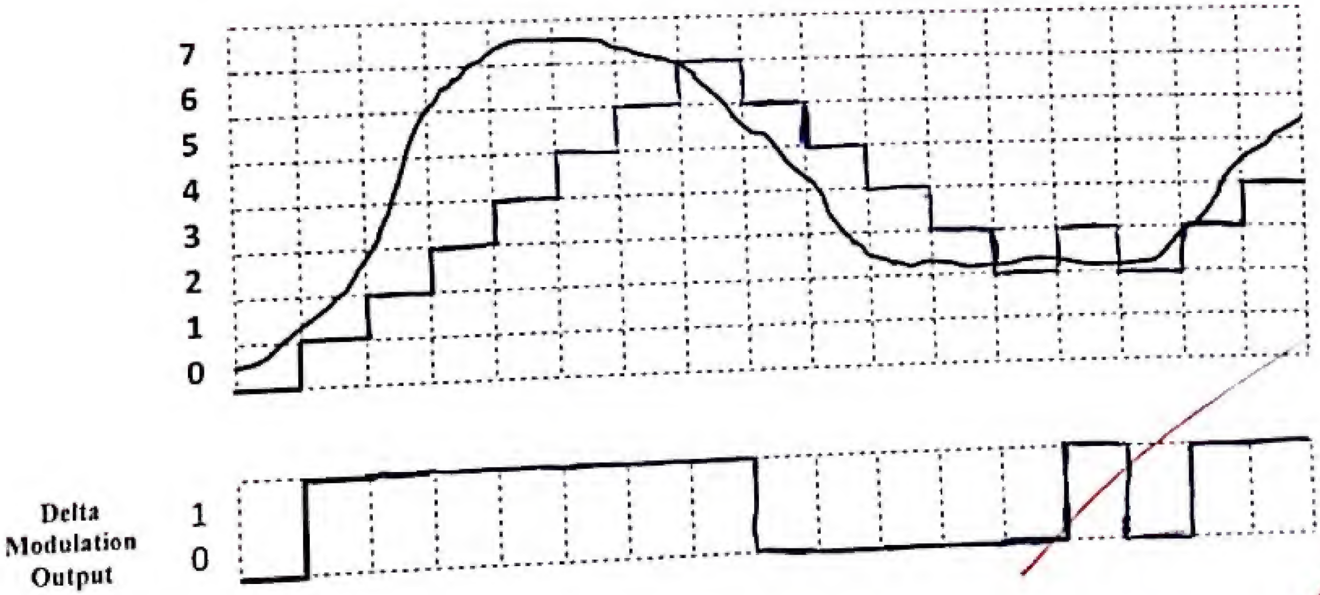
(ii) **(½ Point)** PCM output.



(c) **(2 Point)** Using **delta modulation** and the following analog waveform:

(i) **(1 Point)** Draw the staircase function.

(ii) **(1 Point)** Show the DM output.



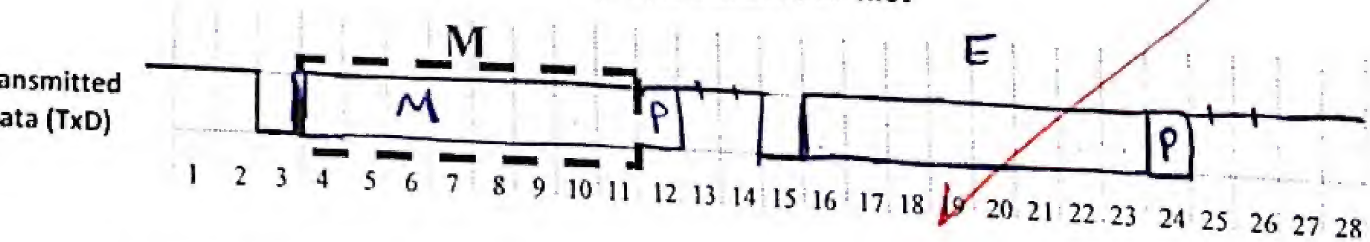
-1

(a) **(2 Points)** A transmission system uses **asynchronous transmission**. It is assumed that each transmitted character has the following format:

- The idle state is logical 1 value. Its length is variable and is zero bits if characters are transmitted back-to-back
- 1 One start bit with logical 0 value
- 8 data bits
- One <u>odd</u> parity bit 1
- Two stop bits with logical 1 values 2

(i) **(1 Point)** If the word "ME" is to be transmitted (with letters back-to-back, i.e. no delay in between), fill in the following figure for the resulting character stream.
Hints:

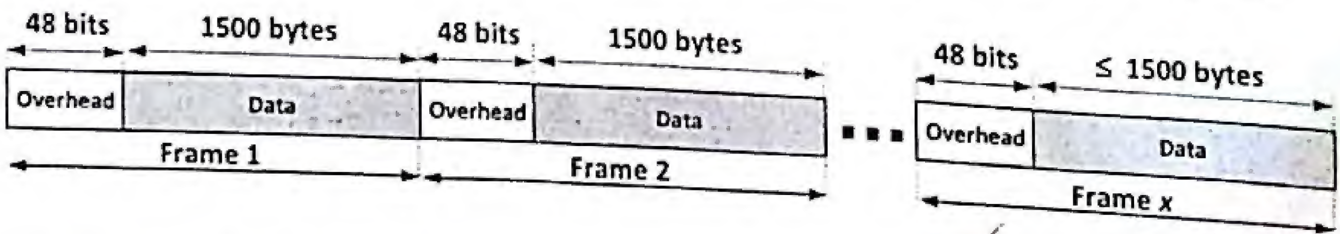
- **No need to include framing characters such as STX and ETX**
- **Given M = 01001101; E = 01000101**
- **The least significant bit (lsb) is transmitted first**



(ii) **(1 Point)** Compute the link efficiency (η).

$n8 = 8+(1+1+2) = 8/12 = 0.66$

(b) **(1 Point)** Suppose a file of 10,000 bytes is to be sent. Assume that the data are sent in frames. Each frame consists of 1500 bytes (at maximum) and overhead of 48 control bits per frame. Calculate the **total overhead in bits using synchronous communication.**



Number of Frame = 7 frames
overhead in bits = 7X48 = 336 additional bits

Question 4 (3 Points) Error Control

Course Learning Outcome #6:
Understand the principles of error detection and control

(a) (1 Point) Compute the odd and even parties for the following 8-bit message:

1	1	0	1	0	0	1	1	? 0

Odd Parity

1	1	0	1	0	0	1	1	? 1

Even Parity

(b) (2 Points) The following message **1 0 0 1 1 0 1 1** is to be transmitted across a data link using CRC for error detection. A generator polynomial $x^4 + x^3 + 1$ is to be used. Find the contents of the transmitted frame T(x).

```
11001 ) 1 0 0 1 1 0 1 1 0 0 0 0
        1 1 0 0 1
        -1 0 1 0 0
         1 1 0 0 1
         -1 1 0 1 1
          1 1 0 0 1
          -0 0 1 0 1
           0 0 0 0 0
           -0 1 0 1 0
            0 0 0 0 0
            -1 0 1 0 0
             1 1 0 0 1
             -1 1 0 1 0
              1 1 0 0 1
              -0 0 1 1 0
               0 0 0 0 0
               -0 1 1 0   ← R(x)
```

$\underbrace{0110}_{R(x)}$

→ T(x) = $\underbrace{10011011}_{T(x)}$ 0110